Genetic Variation in Ability to Withstand Transplanting Shock[1/]

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INTRODUCTION

Is there genetic variation in ability to withstand transplanting shock? If there is, this would be of extreme importance in tree improvement programs. A fast growth rate strain that survives poorly is useless. There have been many articles that have considered survival in connection with racial variation studies. However, most of the survival assessments were made at the end of the growing season and there is no record of attempts to follow survival of individual tree progenies. Langdon in 1958 reports on the early survival of different seed sources of slash pine in South Florida and Minckler reported on genetic differences in survival of one parent progeny tests with loblolly pine in the Journal of Forestry in 1942. However, his survival estimates were determined at the end of the fourth growing season and involved only one planting date on one site.

A study of genetic differences in ability to withstand transplanting shock was made with slash pine at the University of Florida in 1956 by the junior author. Differences in survival amongst half-sib progenies ranged between 90% and 15%. However, because of variability between blocks the results would be explained by chance alone in one out of ten similar experiments. These results justified a more exhaustive study of the possible significance of genetic differences in transplantability for tree improvement. For this purpose we collected seed from thirty open-pollinated mother trees located in 3 stands in the Piedmont of North Carolina. The seed from each mother tree was kept separate and planted in 5 replicated blocks in the nursery in accordance with the procedure recommended by Wakely et al in 1962. Wakely's nursery planting design is arranged so that the nursery effects are preserved in the outplanting design and hence can be removed from the total sums of squares in experimental results. The field design consisted of 5 randomized blocks with each of the 30 mother trees represented by one row of 20 seedlings in each block, thus a total of 100 seedlings were represented for each mother tree. This design was replicated in one location on 5 planting dates six weeks apart from December to June. A separate planting was made in the N. C. sandhills to test survival ability under stress conditions.

The planting site near Raleigh, North Carolina was a good bottom-land site with abundant moisture; the soil of the planting area was primarily a clay--loam. Seedlings were outplanted in this area at 1 ft. x 1 ft. spacing. A total of 15,000 seedlings were set out on the 5 planting dates in the Raleigh nursery. From the bundle of seedlings listed from each block on each planting date 2 seedlings were chosen at random for root-shoot ratio and height measurements and 2 others were chosen for root regeneration potential studies. Twenty remaining seedlings from the bundle were selected for field planting. Planting was so arranged that 2 or 3 men crew planted all seedlings in one block. Thus the differences due to planting technique were the same within each replication. The time required to plant 3000 seedlings on each planting date varied from 3 to 7 hours except on the first planting date which required parts of three days.

RESULTS

Except for the first planting date all observations on survival were made within 30 to 60 days after the planting. About six weeks are required before dead and dying seedlings show distinct moribund symptoms. A second survival observation was made at the end of the growing season. Significant differences were generally the same for both observation times, but greater variation occurred within blocks in the winter measure of survival due to the severe weed competition that had developed during the summer season. This paper reports on the observations of mortality to 60 days after outplanting. Fig. 1 illustrates the variation in survival for 4 of the progenies on the various planting dates. For simplicity only four progenies are included in figure 1, although thirty progenies were included in the test.

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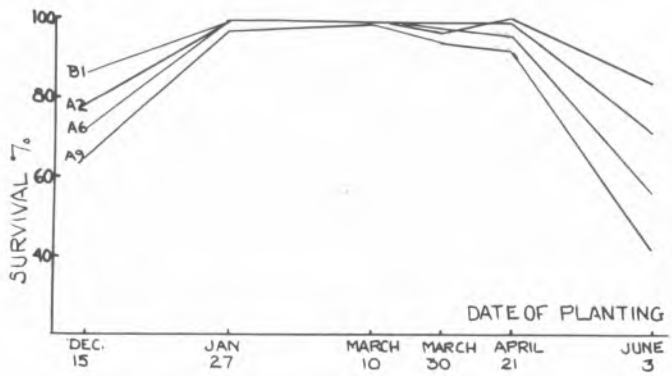

Table 1 -- % Survival of all progenies.

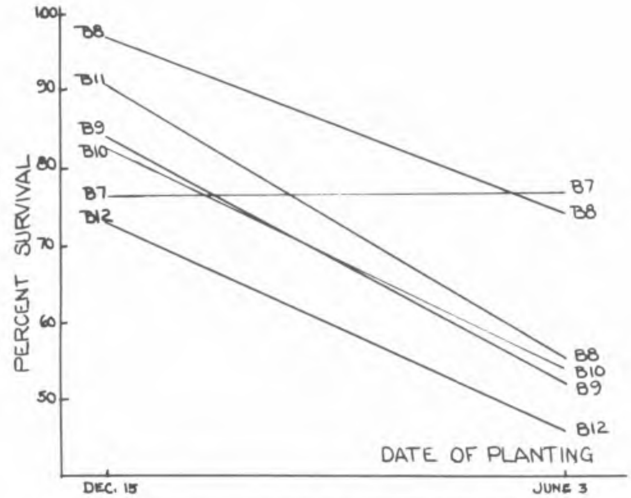

Figure 2 -- Percent survival of selected progenies planted December 15 and June 3. Note the change in rank of some progenies on the two planting dates.

Table 1 gives the percent survival for all progenies on all planting dates.

On planting date one, two and five, the differences in survival were too great to be explained by chance along. Hence the conclusion that there are genetic differences in ability to withstand transplanting shock is most reasonable. Note that progeny A-9 gave an inferior survival performance on all planting dates recorded. The probability that the low survival rank of progeny A-9 on all planting dates can be explained by chance or sampling error is infinitesimally small. Correspondingly, the consistently superior survival rank of other progenies is equally impressive.

Figure 2 illustrates the shift in position of rank in percentage of survival for a number of progenies for the first and fifth planting dates. There were other shifts in survival percent with time. Evidently factors which favored survival for one genotype at one time of the year were disadvantageous at another in some instances. The spring of 1964 was one that was highly favorable to survival of transplanted material, and, for most planting dates, the survival of all progenies was between 94 and 96%. However, for the December and June planting dates survival ranged between 40 and 77% for individual progenies. In spite of the favorable season we found distinct differences in ability to withstand transplanting shock. A more adverse transplanting season would have resulted in significant differences in survival on all Planting dates. The second phase of these investigations was centered on attempting to develop an explanation for the observed genetic differences in ability to survive transplanting.

We found no correlation between the percentage of survival and date of flushing. We did find a correlation between root regeneration potential and ability to survive. Root regeneration potential was measured after the method of Stone (1955) at the University of California: The roots on several seedlings were removed at the time of transplanting and the number of new roots at the end of the 30 day period was recorded. There was a fair correlation between the number of new roots formed in

Table 1.

SURVIVAL BY PLANTING DATES

Planting Date	A2	A6	A9	A10	A12	A13	B1	B2	B3	B4
PD1	78	72	65	91	66	62	86	77	70	92
PD2	100	100	97	99	100	100	100	100	100	100
PD3	100	100	99	100	98	100	100	100	98	100
SH	98	99	94	99	98	95	97	98	97	100
PD4	96	99	92	95	100	97	100	99	98	99
PD5	56	71	41	48	53	61	84	59	52	72
	528	541	488	532	515	515	567	533	515	563
Av.	88.0	90.17	81.33	88.67	85.83	85.83	94.5	88.83	85.83	93.83

Planting Date	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2
PD1	80	68	76	97	84	83	91	73	88	83
PD2	100	100	100	100	100	100	100	96	100	100
PD3	100	100	98	100	100	100	100	98	99	100
SH	97	89	96	99	99	97	100	95	98	99
PD4	97	98	97	99	97	98	98	96	98	96
PD5	49	39	77	74	52	54	55	46	50	54
	523	504	544	569	532	532	544	504	533	532
Av.	87.17	84.0	90.67	94.83	88.67	88.67	90.67	84.0	88.83	88.67

Planting Date	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
PD1	66	77	85	81	71	79	77	78	61	75
PD2	100	100	99	98	100	99	100	100	100	100
PD3	100	100	100	99	100	100	100	100	100	100
SH	97	99	97	99	99	98	97	98	98	100
PD4	98	99	100	100	96	93	100	99	98	96
PD5	48	81	43	40	54	45	50	61	77	71
	509	556	524	517	520	514	524	536	534	542
Av.	84.83	92.67	87.33	86.17	86.67	85.67	87.33	89.33	89.0	90.33

PD = planting date

% Survival	Range	Average		Range	Average
PD1 = Dec. 15	61-97	77.7	SH(sandhills)		
PD2 = Jan. 27	96-100	99.6	March 30	94-100	97.8
PD3 = March 10	98-100	99.6	PD4 = April 21	92-100	97.6
			PD5 = June 3	40-77	57.2

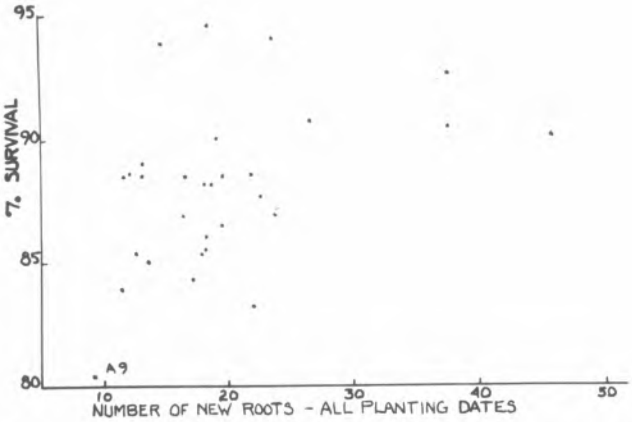

Figure 3 -- Note the fair correlation between percent survival and the number of new roots formed by the different progenies.

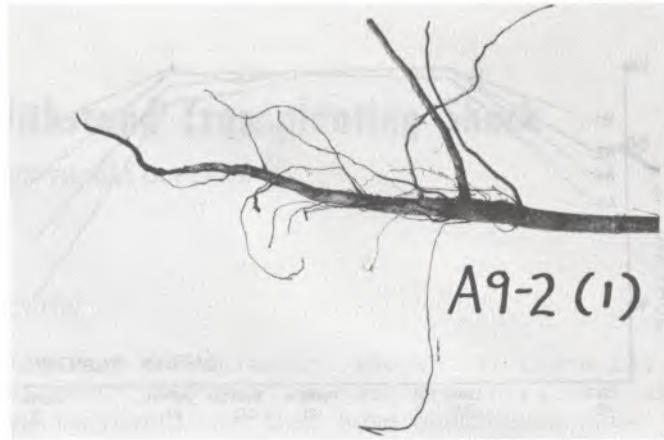

Figure 4 -- Representative root system of progeny A 9. Note the contrast in the fleshy but sparse root systems of progeny A 9 with the fibrous root system of progeny C

30 days and the percent survival. This is illustrated in Fig. 3

An attempt was made to correlate the percentage of survival with the root-shoot ratio; that is, the ratio of the dry weight of the roots to the dry weight of the shoot. A slight correlation was found. This does not mean that,there is no correlation between survival and the balance between root and shoot. The measurement of root-shoot ratio by the methods we used leaves much to be desired. Heavy, fleshy, tap roots with few laterals and little absorp' tive ability may weigh as much or more than fibrous root system as illustrated with progeny A-9, a poor survivor, and progeny C-12, a good survivor, figures 4 and 5. Progeny C had average root-shoot ratio, but the root system was generally more fibrous than others investigated. In the process of lifting the plants in the nursery, all were pruned back to 8 inches and this, too, may have lessened the correlation between root-shoot ratio and survival. Root pruning at lifting time may also explain the negative correlation between height of the plants and percent survival (See figure 6). Percent Survival = 112.3-1.259 height, r = 0.59. It should be noted again that root-shoot ratio is correlated with the size of the plant per se, and undercutting nursery beds before lifting in the nursery has the effect of creating a severe imbalance of root-shoot ratio for large seedlings.

The results of the studies on genetic differences in transpiration rate are most interesting. Ten seedlings from each of the 30 mother trees were placed in pots. After the plants were well established, the pots were wrapped with polyethylene, so that any loss of water was through the plants themselves. The plants were weighed in 4-day intervals and the amount of loss per day was calculated. The results were recorded for 20 days, since, as indicated in figure 7, the transpiration rate becomes low under the conditions of severe stress that prevail after 20 days without water. The plants were ranked according to their transpiration loss in grams per day and these were correlated with the ability to survive transplanting shock. It is interesting to note that when we plot percent survival versus grams of transpiration per day for a plant that we have a negative correlation without too good a fit

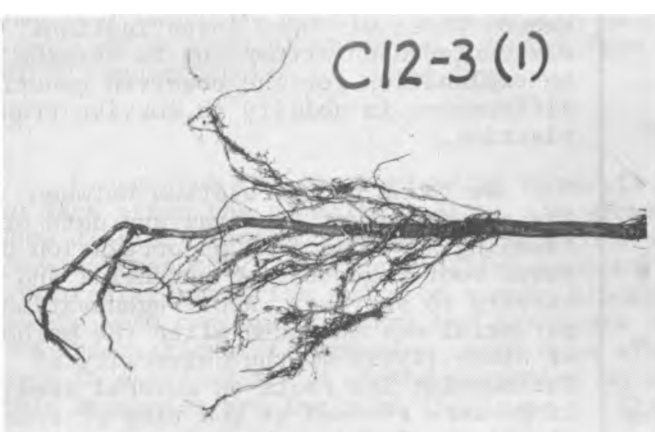

Figure 5 -- Representative root system of progeny C 12. Compare with root system of progeny A 9 (figure 4).

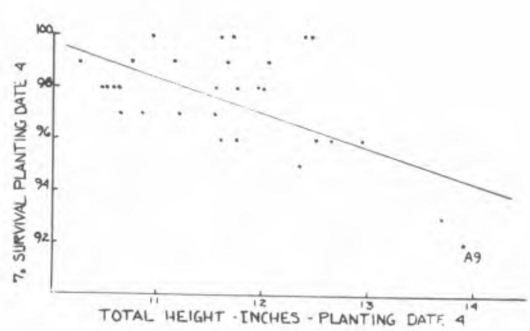

Figure 6 -- Negative correlation between total plant height and percent survival--is possibly the result of root pruning at lifting time.

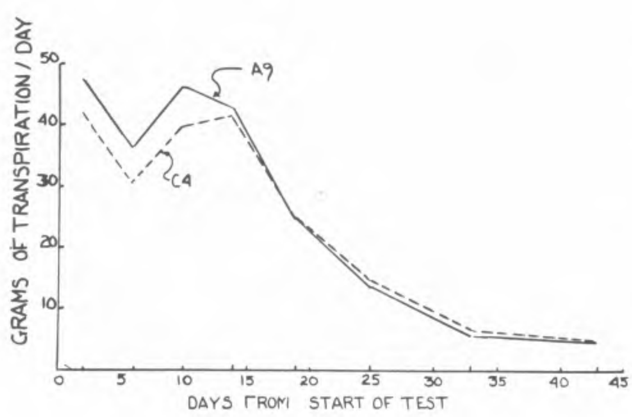

Figure 7 -- Variation in rate of transpiration per day with time since last watering (moisture stress).

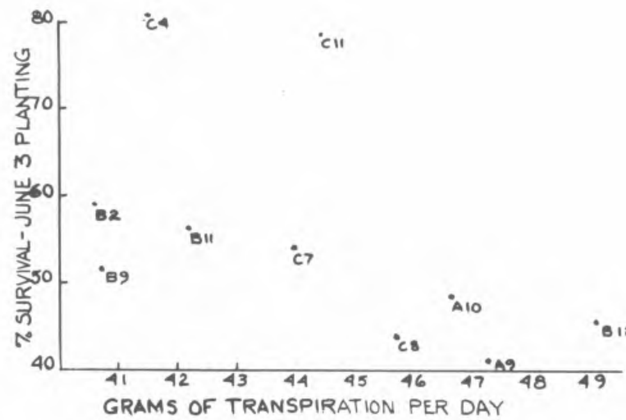

Figure 8 -- Note the slight negative correlation between grams of transpiration per plant per day and percent survival.

to the data as per figure 8. However, when this data is converted to transpiration per gram needle weight, we see that there is positive correlation for transpiration per needle weight and percent survival (See Figure 9). Perhaps these results can be explained in terms that transpiration is dependent upon the development of an effective root system. In those plants that are able to develop effective root system we are able to have good survival percentages. Dr. Maki working in the Southern Forest Experiment Station found that the transpiration in plants bore a direct linear relationship to the size of the root system of the plants.

SUMMARY

The results of this series of investigations show clearly that there are genetic differences among progenies in ability to withstand the shock of transplanting. Progeny A-9 of the thirty plants investigated is an example of a plant that characteristically has low survival percentages on all planting dates studied, while progeny B-8 gave a superior planting survival on all dates studied. Attempts to find physiological bases for some of these observed differences in ability to withstand transplanting shock showed that there are genetic differences in plant size, plant height and root-shoot ratio, root habit and root regeneration potential. All of these characteristics are correlated with ability to withstand transplanting shock. There are genetic differences in transpiration rate on a per plant basis and on a per gram of needle weight basis. The general evidence indicates that the factors that cause some progenies to survive well at one time of the year are not correlated with the good survival at other times of the year. One surprising observation is the positive correlation between transpiration per gram of needle weight and percent survival, while there is a negative correlation between the total transpiration per plant and percent survival.

LITERATURE CITED

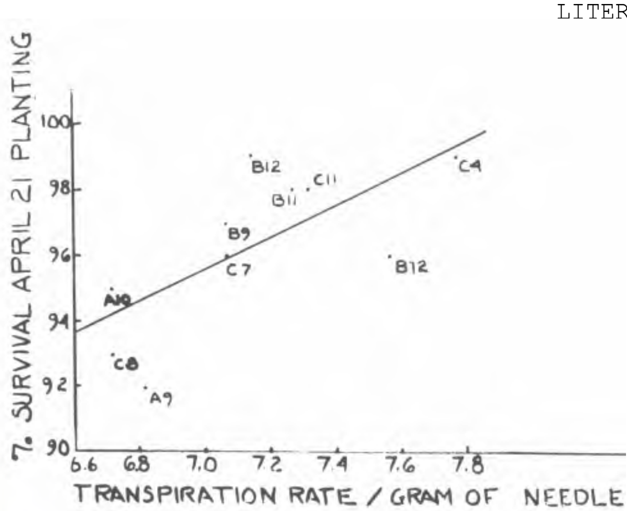

Figure 9 -- Note the strong positive correlation between grams transpired per cm of leaf surface and percent survival.

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